Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE OPHIOBOLUS CAUSING TAKE-ALL OF WHEAT

H. M. Fitzpatrick, H. E. Thomas, and R. S. Kirby

(With Plate 10 and 1 Text Figure)

The discovery of perithecia of a species of *Ophiobolus* in July, 1920, at East Rochester, New York, on wheat plants showing characteristic symptoms of the take-all disease was reported in an earlier paper.[1] Subsequently additional collections of the fungus have been made in scattered localities in New York, and reports of its occurrence in other states have been received. The fungus has also been obtained in pure culture, and repeated inoculations have demonstrated it to be the causal organism of the take-all disease. Normal perithecia with mature asci and spores have developed in culture, and a comparative study shows the organism used in the inoculations to be identical with that collected in the field. A paper dealing with the various aspects of the experimental work and embracing a discussion of the parasitism of the fungus has been submitted for publication.[2] In the present paper only facts bearing on the identity of the organism are considered.

In the historical and bibliographic discussion of the take-all disease prepared by Stevens[3] a number of papers are cited in which the discovery of perithecia of *Ophiobolus* in connection with diseased plants is reported. Two species, *O. graminis* Sacc. and *O. herpotrichus* (Fr.) Sacc., are mentioned repeatedly. It has seemed necessary to compare our fungus carefully with these and other species of *Ophiobolus* occurring on grasses, as well as with various foreign collections of *Ophiobolus* associated with the take-all disease. Moreover, the economic importance of the disease has made desirable the publication of an illustrated description of the fungus for the use of those who are searching in various sections of the country for infected plants. This is particularly true since the published descriptions of grass-inhabiting species of *Ophiobolus* in most cases are brief and more or less inadequate.

---

[1] Kirby, R. S., and Thomas, H. E. The take-all disease of wheat in New York. Science, N. S. **52**: 368–369. 1920.

[2] Kirby, R. S. The take-all disease of cereals and grasses. Phytopathology for January, 1922. (Abstract of paper presented at annual meeting of Phytopathological Society at Toronto, December 28, 1921. Complete paper not yet published.)

[3] Stevens, F. L. Foot-rot disease of wheat—historical and bibliographic. Bull. Nat. Hist. Survey. Illinois Dept. Registration and Education **13**: 259–286. 1919.

Through the coöperation of several foreign correspondents the comparison of the American collections of the fungus with material from other countries has been accomplished. Specimens of *Ophiobolus* on wheat from three different localities in England were mailed for our examination by Doctor Cotton. Three collections on wheat and barley from various parts of Japan were submitted by Doctor Miyabe, one on barley from Italy was received from Professor Peglion and Mattirola, and a single collection from France was sent by Professor Foex. In all cases the fungus had been found associated with the typical symptoms of the take-all disease, and in every instance the material was labeled *O. graminis* Sacc. A critical examination of the various collections, including a comparative study of perithecia, asci, and spores, shows the fungus to be identical in every case with the American material. Furthermore, specimens collected in New York have been submitted to Professor McAlpine, and he writes: "I have carefully examined the specimens sent by you and on comparing the mycelium, perithecia, and spores have come to the conclusion that it is the same fungus as that occurring on Australian wheat." There can be no question, therefore, of the propriety of applying the name take-all to the disease of wheat in this country.

The fungus agrees in general with the descriptions of *O. graminis* given by Saccardo,[4, 5] and with the description and figures of this species published by Berlese.[6] There are certain minor points of difference, and for this reason the examination of the original collection is desirable. However, the herbarium of Saccardo has been practically unavailable since his death, the col-

---

[4] Saccardo, P. A. Fungi veneti novi vel critici. ser. II. Nuovo Giornale Botanico Italiano **7**: 307. 1875. (*Rhaphidophora graminis* Sacc.)

[5] Saccardo, P. A. Sylloge fungorum **2**: 349. 1883.

[6] Berlese, A. N. Icones Fungorum **2**: 119–120. Pl. 146, fig. 2. 1899.

lections having been kept in his home pending the action of the administrator of the estate. Through the kindness of Professor O. Mattirola it nevertheless has been possible to get in touch with the son, Professor D. Saccardo, and he has visited the herbarium and mailed us a fragment of material from a specimen labeled "*Ophiobolus graminis* exempl. Mad. Libert." This is probably the type collection, as the species was based on material in the herbarium of Libert.[7] Unfortunately, however, the material submitted is worthless, since it bears no perithecia of *Ophiobolus*. A second attempt to obtain material has been made, but has not yet proved successful. It is hoped that it will be possible to publish in a subsequent note information concerning the type specimen, but until the herbarium is made more readily available this may not be possible.

Berlese states that he examined the original collection of *O. graminis* in the herbarium of Saccardo, and that the figures of perithecia, asci, and spores given by him were drawn from it. His drawings of the perithecium indicate that the organism studied is identical with our own, and although the spores as figured by him are more slender than those of the take-all fungus, it is probable that they were drawn inaccurately, since they do not correspond with his description. In fact, his measurements of perithecia, asci, and spores agree so closely with those obtained by us for the take-all organism that its identity with *O. graminis* can hardly be questioned. His failure to mention paraphyses, and his statement that the spores are only tri-septate, are probably due to his having seen only a small amount of relatively unfavorable herbarium material. Since his description agrees with that of Saccardo, there seems to be no reasonable justification for questioning his statement that the figures were drawn from the type collection. He asserts further that he compared this material with the type collections of *Sphaeria eucrypta* Berk. & Br. and *S. cariceti* Berk. & Br. and found the three species to be identical. Moreover, he accepts the oldest specific name and designates the species as *O. eucryptus* (Berk. & Br.) Sacc.

---

[7] Roumeguere, C., et Saccardo, P. A. Reliquiae mycologicae Libertianae, series altera. Revue Mycologique 3: No. 11. 39–59. Pl. 19, 20. 1881.

In the endeavor to corroborate Berlese's statements an attempt has been made to obtain from the herbarium of the Royal Botanic Gardens at Kew portions of the original collections of these two British specimens. Since both species antedate *O. graminis,* the demonstration of the correctness of Berlese's assertion with reference to either would force us to discard the specific name *graminis.*

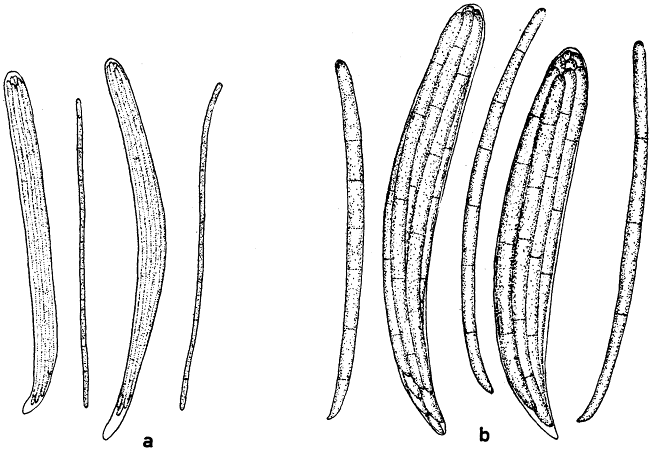


FIG. 1. *a,* Asci and spores of *Ophiobolus eucryptus,* from material collected by Broome on *Iris foetidissima.* × 625; *b,* Asci and spores of *O. cariceti,* from material collected in New York on wheat showing typical symptoms of the take-all disease. × 625. (Camera lucida)

Miss Wakefield has very obligingly mailed to us from Kew material bearing on this nomenclatorial problem, and accompanying the material has written as follows:

"*Sphaeria eucrypta* B. & Br. There seems to be no type of this (on *Carex pendula*) in existence. We have 5 specimens collected by Broome, but all are on *Iris foetidissima.* I send you a slide of one of these—collected at Batheaston, Jan., 1859.

"*Sphaeria cariceti* B. & Br. The type of this in Berkeley's own herbarium (Batheaston, Dec., 1858) does not seem to have any mature perithecia left. I found some in another specimen from Cooke's herbarium collected by Broome. This is labelled in Broome's handwriting 'on *Aira caespitosa,* Batheaston, Jan., 1850,' but the name '*Sphaeria cariceti* B. & Br.' has been added at another time in rather different handwriting, which I doubt being that of

Broome. However, there are no specimens in Broome's herbarium at the British Museum,—so I am sending you a slide of this one, as it seems probably authentic."

In addition to the slides showing asci and spores, fragments of leaf sheaths showing perithecia were also sent to us, and a careful comparison of these specimens with material of the take-all organism was made.

The perithecia of *S. cariceti* as shown in the type specimen in Berkeley's herbarium have been examined and found to agree closely in size, shape, and other characters with those of our own organism. Their position on the host is also the same. Moreover, the asci and spores in the specimen from Cooke's herbarium are indistinguishable from those of the fungus of take-all. (Text Figure 1*b*.) There is, in fact, no point of evident difference between our organism and *S. cariceti* as seen on *Aira caespitosa* in these two specimens at Kew. Since asci and spores can not be obtained from the type specimen, it is not possible by a comparison of specimens alone to demonstrate that the material in the herbarium of Cooke is unquestionably *S. cariceti*. However, it agrees completely with the rather brief original description of the species given by Berkeley and Broome.[8] Fortunately, moreover, accompanying the description, drawings of an ascus and two spores are given which agree well in size and shape with the material in the herbarium of Cooke and with our own material of the take-all fungus. The spores as drawn are non-septate, but the arrangement of the guttulae indicates that at maturity a septation corresponding to that in the Cooke material would occur.

Since the perithecium of *S. cariceti* as seen in the type specimen is characteristic and agrees completely with that of the take-all organism, there would be on this basis alone considerable justification for regarding the two as the same. When as corroborative evidence the available data concerning the asci and spores are considered the identity of the two forms does not admit of a reasonable doubt.

The perithecia of the fungus from *Iris foetidissima* labeled *S. eucrypta* B. & Br. differ in several essential respects from those of *S. cariceti.* Instead of lying beneath the outer leaf sheath as in the latter species they occur within the tissue of the sheath itself. They possess much shorter beaks, lacking any pronounced tendency toward curvature, and protrude less evidently. The spores, although of about the same length, are considerably narrower and more flexuous. The asci are also correspondingly narrower. (Text Figure 1*a*.) In fact, the fungus differs strikingly from *S. cariceti* in several respects, the spores, though different, constituting the most evident point of resemblance. Since this material is not the type collection, and since it was found on another host plant, the possibility exists that it is not in reality *S. eucrypta.* It agrees, however, with the original description[9] of this species, except in the possession of somewhat longer spores, and is probably identical with it. In the original description the spores are said to be one five-hundredth of an inch (50μ) in length. Saccardo states erroneously that they measure 125μ. Since his description is based on that of Berkeley and Broome, this is merely an evident error in conversion of inches to microns, and has already been noted by Berlese, who gives the dimensions as $70–74 \times 3\mu$. Even if it were assumed that the type collection of *S. eucrypta* was in fact a different organism from that on *Iris foetidissima* there would be no justification for the assumption that it was identical with *S. cariceti.* The original descriptions of *S. eucrypta* and *S. cariceti* and the drawings which illustrate them are clearly based on two different species, and it is evident that Berlese was in error in regarding them as identical. Also it is evident that the name *Ophiobolus graminis,* widespread in the literature of the take-all disease, must be supplanted by the less familiar name, *O. cariceti* (B. & Br.) Sacc. If the examination of the type specimen of *O. graminis* shows it to be identical, as we believe, with *O. cariceti* the Saccardo name, being more recent, must be relegated to synonomy. If, on the other hand, it should prove to be specifically distinct, it will then have no significance in connection with the take-all disease.

---

[8] Berkeley, M. J., and Broome, C. E. Notices of British Fungi. Ann. and Mag. Nat. Hist. 7: ser. 3. 455. Pl. 17, fig. 35. 1861.

Several other species of *Ophiobolus* have been described as occurring on the culms of grasses, but none of them resemble closely the take-all organism. Since several authors have mentioned *O. herpotrichus* in connection with the disease, it, however, must be considered. The perithecia as pictured by Berlese resemble somewhat those of *O. cariceti,* but the asci and spores are very different. The spores are twice as long as those of the take-all organism, and are flexuous, thread-like, multiseptate, and brown. Confusion of the two species, therefore, is impossible.

---

[9] Berkeley, M. J., and Broome, C. E. Notices of British Fungi. Ann. and Mag. Nat. Hist. **9**: ser. 2. 383. Pl. 12, fig. 40. 1852.

Since the published diagnoses of *O. cariceti* are very brief and incomplete, the following description has been prepared. It is based on the specimens of *S. cariceti* received from Kew and on several collections of American and foreign material of the fungus found associated with the take-all disease. Consideration of the appearance of the fungus in pure culture is omitted.

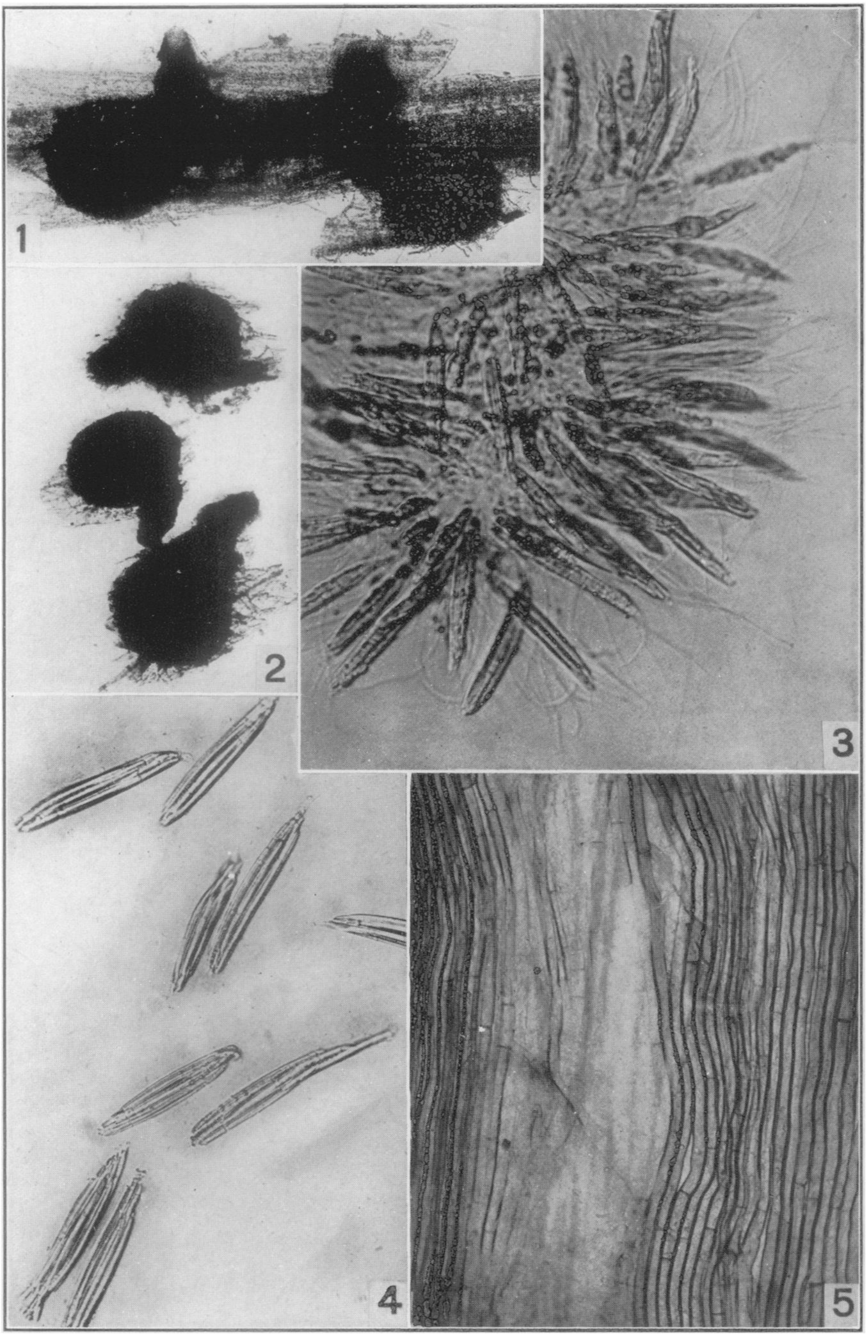
OPHIOBOLUS CARICETI (Berk. & Br.) Sacc., Sylloge Fungorum **2**: 349. 1883.

Sphaeria cariceti Berk. & Br., Ann. & Mag. Nat. Hist. **7**: ser. 3. 455. *pl. 17. fig. 35.* 1861.

? *Rhaphidophora graminis* Sacc., Nuovo. Giorn. Bot. Ital. **7**: 307. 1875.

? *Ophiobolus graminis* Sacc., Revue Mycol. **3**: No. 11. 45, 1881; and Syll. Fung. **2**: 349. 1883.

Mycelium permeating the roots of the host, causing them to become very brittle and easily broken away, developed profusely above the crown of the plant in and about the leaf sheaths, and forming a definite thick plate between the inner leaf sheath and the culm; the mycelial plate (Fig. 5) usually adhering to the culm when the leaf sheaths are stripped away, composed of coarse, dark brown hyphae, three to six microns in diameter, which frequently run rather definitely parallel to one another forming broad, flat, ribbon-like strands resembling somewhat compressed rhizomorphs; perithecia membranaceo-carbonaceous, dark brown to black, smooth, rostrate, ostiolate, occurring on the roots of the host especially within thick wefts of fine rootlets developed abnormally about the crown of the plant, but more frequently observed arising from the mycelium beneath the outer leaf sheath, standing singly or in groups, the individuals in a group occasionally fused laterally but no true stromatic tissue developed, firmly bound to the leaf sheaths by numerous strands of mycelium attached both to the neck and



OPHIOBOLUS CARICETI (BERK. & BR.) SACC.

ascigerous portion, often developed in great numbers, more than one hundred individuals having been counted on a single culm, when young hidden from view but at maturity the beaks protruding and prominent, and by the shredding of the leaf sheath the upper hemisphere of the perithecium often exposed to view; perithecial beak developed obliquely and in the beginning lying more or less parallel to the surface of the culm, later, curving sharply outward, penetrating the leaf sheath and protruding, the obliquely attached curved beak so characteristic of the species as to be almost diagnostic (Fig. 1); ascigerous portion of the perithecium globose or subglobose, though sometimes compressed between the leaf sheaths, 330–500 μ (usually about 425 μ) in diameter, narrowing gradually into the truncate-conoid to cylindrical beak which frequently attains a length as great as the diameter of the ascigerous cavity (Fig. 2); asci (Fig. 4 and Text Fig. 1*b*) numerous, fascicled, elongate-clavate, straight or curved, short stipitate to subsessile, 90–115 x 10–13 μ, rounded at the apex, 8-spored, thin-walled; paraphyses (Fig. 3) abundant, thread-like, flexuous, unbranched, hyaline; ascospores fascicled to sub-biseriate, hyaline, as viewed together in the ascus faintly yellowish, linear, curved, broader at the middle and tapering gradually toward the ends, the upper end rounded, the basal end more acute and sometimes more sharply curved, 60–90 (chiefly 70–80) x 3 μ, when young continuous and multiguttulate, at maturity 5–7-septate, not reaching morphological maturity until late autumn or winter.

Parasitic on wheat, barley, rye, and various wild grasses, causing the take-all disease, apparently cosmopolitan in its distribution.

DEPARTMENT OF PLANT PATHOLOGY,
CORNELL UNIVERSITY,
ITHACA, N. Y.

EXPLANATION OF PLATE 10

Ophiobolus cariceti

All the figures were made from American material collected on wheat plants showing the typical symptoms of the take-all disease.

Fig. 1. Two perithecia developed below the outer leaf sheath. The oblique beaks illustrate one of the most characteristic features of the species. × 35.

Fig. 2. Three perithecia illustrating variation in shape. They are shown as they appear in a microscopic mount after removal from the plant, and no attempt was made to orient them in the erect position. × 35.

Fig. 3. A fascicle of asci and paraphyses. × 240.

Fig. 4. Asci. × 300.

Fig. 5. A portion of the mycelial plate formed about the culm. × 300